Application No.: 10/804244

Docket No.: TAW-008

REMARKS

Applicants amend claim 1 and cancel claims 5-7. Support for the amendment can be found at page 8, lines 11-16. As requested by the Examiner, Applicants affirm the election of Group I, claims 1-7 in response to the Restriction Requirement. Upon entry of this amendment, claims 1-4 are presented for examination. Applicants respectfully submit that claims 1-4 define over the art of record.

The Claimed Invention

The claimed invention is achieved by the finding that shape memory alloy having at least two phases can be turned into a shape memory alloy having high mechanical strength and excellent shape recovery ratio *by controlling its microstructure* comprising a main phase (β-phase) and a sub-phase (γ-phase). See Page 3, lines 18-23.

Claim 1 recites the limitation that at least 40% by area of crystal grain boundaries of the β-phase being occupied by the γ-phase, where the alloy contains 23 to 27 atomic % of Al and 39 to 45 atomic % of Co, the balance being 28 to 38 atomic % of Ni and inevitable impurities. The composition of the Ni-Co-Al alloy *directly affects the area ratio and volume fraction* of the γ-phase existing in the β-phase grain boundaries. The lower the Al content is in the shape memory alloy, the more γ-phase is generated. Hence, low Al content and high Co content provide high volume fraction and area ratio of γ-phase existing in the β-phase grain boundaries whereas high Al content and low Co content provide the low volume fraction and area ratio of the γ-phase existing in the β-phase grain boundaries. See Page 7, lines 16-24.

Additionally, Al affects the mechanical strength and shape recovery ratio of the alloy. The shape recovery ratio is insufficient when the Al content is less than 22 atomic %, and the mechanical strength is insufficient when the Al content is more than 30 atomic %. Additionally, Co also affects the mechanical strength and shape recover ratio of the alloy. The mechanical strength is insufficient when the Co content is less than 20 atomic % and the shape recover ratio is insufficient when the Co content is more than 50%. Hence, the Al content is preferably 22 to 30 atomic % and the Co content is preferably 20 to 50 atomic %. See Page 8, lines 2-10 of the Specification.

When the shape memory alloy is ferromagnetic, the shape memory alloy should include 27 atomic % or less of Al and 39 atomic % or more of Co to achieve the γ-phase area ratio of 40% or more. In order to have high mechanical and sufficient strength shape recovery ratio, the Ni-Co-Al alloy preferably contains 23 to 27 atomic % of Al and 39 to 45 atomic % of Co, the balance being 28 to 38 atomic % of Ni and inevitable impurities. See Page 8, lines 11-16. The % by area of γ-phase in β-phase grain boundaries directly affects both mechanical strength and the shape recovery ratio. Because at least 40% by area of the crystal grain boundaries of the β-phase grain boundaries are occupied by the γ-phase, the shape memory alloy of the claimed invention makes it possible to achieve a satisfactory combination of mechanical strength (tensile strength) of 400-1100 MPa and a shape recovery ratio of 18-75%. See Page 21, Table 1.

The alloy of the claimed invention is made by undergoing a first heat treatment at 1200 to 1350°C for 0.1 to 50 hours, cooling at 0.1 to 1000°C/minute, and undergoing a second heat treatment at 1000 to 1320°C for 0.1 to 50 hours and cooling at 10 to 10000°C/minute. In the two-stage heat treatment, *the γ-phase area ratio can be increased without changing the γ-phase volume fraction* by selecting the desired heat treatment conditions to improve the mechanical strength and shape recovery ratio of the alloy. See Page 12, lines 14-17.

Claim Rejection Under 35 U.S.C. §103

Claims 1-7 are rejected under 35 U.S.C. §103(a) as being unpatentable over the English abstract of JP 2002-129273 (hereafter "JP'273") or "Promising ferromagnetic Ni-Co-Al shape memory alloy system" by Oikawa et al. (Applied Physics Letters, vol. 79, no. 20, hereafter "Oikawa"). The Examiner alleges that the cited prior art teaches substantially a similar composition and the process of producing the same. Applicants respectfully disagree.

The JP'273 Reference

The JP'273 reference teaches a ferromagnetic shape memory alloy that contains 5 to 70 atomic % Co, 5 to 70 atomic % Ni, and 5-50 atomic % Al, the balance being inevitable impurities, where the alloy has a single phase structure composed of a β-phase with a B2 structure or a dual phase structure composed of a γ phase with an fcc structure and a β-phase with a B2 structure. The JP'273 reference is silent about the percentage of area of crystal grain

boundaries of the β phase that is occupied by the γ phase. The JP'273 reference is also silent about the method of producing an alloy with dual phase structure. There is no teaching or suggestion that the alloys taught by the JP'273 reference can exhibit mechanical strength of 400-1100MPa. Although JP'273 teaches an alloy with similar composition, the difference in microstructure of an alloy can significantly affect the properties of the alloy. For example, as set forth above, *the γ-phase area ratio can be changed without changing the γ-phase volume fraction* by selecting different heat treatment conditions to change the mechanical strength and shape recovery ratio of the alloy. Here, the JP'273 reference is silent about the γ-phase area ratio and the method of producing a dual phase alloy; hence it is not obvious to reach the results of the claimed invention in view of the JP'273 reference.

Accordingly, the limitation of *at least 40% by area of crystal grain boundaries of the β-phase being occupied by the γ-phase*, wherein the alloy contains 23 to 27 atomic % of Al and 39 to 45 atomic % of Co, the balance being 28 to 38 atomic % of Ni and inevitable impurities, as recited in amended claim 1 is not taught or suggested by the JP'273 reference. Applicants respectfully request the Examiner reconsider and withdraw the rejection of claim 1.

The Oikawa Reference

The Oikawa reference teaches a ferromagnetic shape memory alloy that contains 27-32 atomic % Co, 30-45 atomic % of Ni, the balance being Al and unavoidable impurities, where the alloy has a single phase or dual phase structure composed of a γ phase with an fcc structure and a β phase with a B2 structure. The alloy is provided by hot rolling of ingots at 1573K followed by cold rolling at room temperature. The Oikawa reference further teaches that specimens of the two-phase ($\beta + \gamma$) alloy 150 μm thick, and Co40Ni33Al27, with about 7 vol % γ, underwent heat treatment twice, once at 1623K for 2 minutes and another at 1573K for 15 minutes. See Oikawa, Page 3292, left column.

In contrast, amended claim 1 recites an alloy with different compositions: 39 to 45 atomic % of Co and 23 to 27 atomic % of Al, the balance being 28 to 38 atomic % of Ni, where the % range of Co in claim 1 does not overlap with the alloys taught by the Oikawa reference. The Oikawa reference is silent regarding the γ-phase area ratio, which is significant in the

claimed invention because it affects the mechanical strength and shape recovery property of the alloy.

Furthermore, the claimed invention teaches a different method for processing and production of the alloys in order to have good mechanical strength and shape recovery ratio. The present application discloses specific method steps that include specific temperature ramping rates, hold temperatures and times, and cooling rates for both stages of the heat treatment. The Oikawa reference teaches a different process and processing times. The Oikawa reference teaches the method of processing alloys using the hot rolling method, which is known to alter the microstructure of alloys. In other words, hot rolling an alloy is different from one stage or two stage heat treatment and the resultant alloy will have a different microstructure. Hence, it is not obvious that the teachings of the Oikawa reference can produce the claimed alloy.

Accordingly, Applicants respectfully submit that the Oikawa reference does not teach or suggest the limitation of *at least 40% by area of crystal grain boundaries of the β-phase being occupied by the γ-phase*, wherein the alloy contains 23 to 27 atomic % of Al and 39 to 45 atomic % of Co, the balance being 28 to 38 atomic % of Ni and inevitable impurities, as recited in amended claim 1. Applicants respectfully request the Examiner reconsider and withdraw the rejection of claim 1.

Applicants note that the dependent claims also recite patentable subject matter. As such, for this and the reasons set forth above, Applicants respectfully submit that the dependent claims also define over the art of record.

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CONCLUSION

In view of the above amendment, Applicants believe the pending application is in condition for allowance.

Applicants believe no fee is due with this statement. However, if a fee is due, please charge our Deposit Account No. 12-0080, under Order No. TAW-008 from which the undersigned is authorized to draw.

Dated: August 29, 2006

Respectfully submitted,

By _____

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